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SUMMARY OF EXPERIMENTS WITH DDT TO CONTROL THE JAPANESE BEETLE

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Studies with technical DDT for the control of the immature stages of the Japanese beetle (Popillia japonica Newman) in the soil and for the protection of fruit and foliage from attack by the adult beetle were conducted in Maine, Massachusetts, Vermont, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, and Ohio. This report summarizes the results obtained during the period from 1943 through 1946.

Formulation of DDT Dusts and Sprays

When this study was undertaken, few commercial preparations of DDT were available, and it was necessary to prepare special dusts and sprays. Later commercial formulations were used. In general, it was found that the effectiveness of the treatment was dependent more upon the amount of DDT applied than upon the formulation.

Dusts.--The dust formulated at the laboratory for the treatment of turf and cultivated land contained 10 percent of technical DDT, 87 percent of pyrophyllite or talc, and 3 percent of tricalcium phosphate. The DDT was micronized2/ with an equal weight of pyrophyllite or talc and then mixed with additional diluent and

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2/ This material was micronized through the courtesy of the Micronizer Processing Company, Inc., Moorestown, N. J.

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tricalcium phosphate. This dust flowed freely in the mechanical seeder and spreader, and when 250 or more pounds were applied per acre a uniform distribution was obtained. Later it was found that commercial dusts containing pyrophyllite or talc were satisfactory, but that those made with a clay were too adhesive to flow properly in this equipment.

The amount of DDT required for the treatment of potting soil is very small. For this treatment the 10-percent dust was diluted further so that it contained 2 percent of DDT, or a commercial dust of this concentration was used, in order to have the material of sufficient bulk that it could be mixed uniformly throughout the mass of soil.

For dusting foliage the amount of DDT in the dust was governed by the type of equipment. A 10-percent dust was used in the small hand dusters, and a 1-percent dust was used when the treatment was applied by airplane.

Water-dispersible DDT.--In the early tests with sprays the technical DDT was micronized with an equal weight of pyrophyllite, and fish glue equivalent to 1/16 of the weight of the solids was added as a wetting agent while the material was being prepared for spraying. Later it was found that the commercial water-dispersible DDT was equally as effective as the foregoing spray and much easier to handle in the field. Sprays prepared from 25 to 50 percent water-dispersible powders to contain the same amount of DDT per 100 gallons were equally effective in protecting plants from attack by the adult beetle, but when the powder contained much less than 50 percent of DDT an objectionable conspicuous deposit was left on the fruit and foliage. Throughout this paper, wherever mention is made of the use of DDT in water suspension, the quantity indicated refers to the quantity of actual technical DDT, in the form of a water-dispersible powder, unless otherwise stated. In the earlier experiments summer-oil emulsion was used with the water-dispersible powder as a sticker; later it was found that the addition of a sticker was not necessary and that it tended to leave an excessive residue of DDT on the fruit.

DDT emulsions.--Two commercial DDT emulsions were applied by an airplane. One contained 30 percent of DDT with a methylated naphthalene as a solvent, and the other contained 25 percent of DDT with an aromatic petroleum derivative.

DDT solution.--A solution of DDT was applied by airplane and also from the ground by a mist blower. This solution contained

1 pound of DDT in 1 quart of xylene and 3 quarts of deodorized kerosene.

Protection of Plants from Attack by Adult Beetles

Since adult Japanese beetles usually attack the upper portion of a plant and then work downward and inward until they have consumed all the fruit and foliage, in applying experimental sprays and dusts care was taken to cover all portions, particularly the extending branches at the top.

The sprays and dusts killed many of the beetles that were hit during the application, and the residue on the plants afforded protection against beetles that came subsequently to them. DDT does not seem to be a strong repellent, since the residue did not prevent beetles from alighting on the sprayed or dusted plants. However, the beetles that walked over or started to feed on these plants soon became paralyzed and died.

DDT was used under many conditions to protect various crops and ornamentals from injury by the adult beetles. The tests conducted and the results obtained may be summarized briefly as follows:

Apple.--In 1944, 1945, and 1946 at Bridgeton, N. J., one application of a spray containing 1 pound of DDT per 100 gallons of water to Yellow Transparent and Williams Early Red apple trees early in July, just as the beetles were beginning to attack them, afforded complete protection to the fruit, which was harvested by the middle of July, and to the foliage throughout the summer. An application of this spray to Williams Early Red apple trees on May 31, as a substitute for the last arsenical cover spray for the codling moth, was inadequate for control of the Japanese beetle, because new growth during June and July was not protected from attack.

Nectarine.--A few nectarine trees at Dayton, N. J., were sprayed with DDT, 1 pound per 100 gallons of water, in 1943 after the beetles had become established on them and were causing severe damage to the fruit. All the beetles on these trees were destroyed and no further injury occurred. The adjacent trees, which were not sprayed, were completely defoliated, and all the fruit was consumed by the beetles.

Peach.--In New Jersey peaches ripen from the middle of July until late in September. The foliage of all varieties is subject to

attack by the beetle, and the fruits of the early-ripening varieties are often severely damaged. In 1943 through 1946 blocks of bearing trees in commercial orchards at Cranbury and Bridgeton, N. J., were sprayed with water-dispersible DDT. The following varieties were in these blocks:

Cumberland	J. H. Hale	N. J. 135	Sunhigh
Elberta	Newday	Raritan Rose	Triogem
Goldeneast	N. J. 109	Redrose	
Goldenglobe	N. J. 118	Summercrest	

Sprays containing 1/4, 1/2, 3/4, and 1 pound of DDT per 100 gallons were applied early in July as the beetles were beginning to invade the trees. All these sprays killed many of the beetles on the trees at the time of application, but only the spray containing 1 pound of DDT afforded complete protection to the fruit and foliage throughout the summer.

Plum.--At Dayton, N. J., in 1943, a few nonbearing young plum trees were heavily infested and partially defoliated by the beetles. Spraying with DDT at the rate of 1 pound per 100 gallons destroyed all the beetles and no further injury occurred.

Grape.--Japanese beetles attack the foliage of all varieties of grapes and damage the berries of those varieties which ripen during August. Most of the vines grow rapidly during July, so that more than one application of a spray is required to protect the foliage. From 1943 through 1946 experiments with DDT were conducted in a commercial vineyard at Holmdel, N. J. When 1/2 to 1 pound of DDT was added to 100 gallons of bordeaux mixture in the preblossom, petal-fall, and pea-stage sprays for control of the grape berry moth (Polychrosis viteana (Clem.)), the last spray being applied late in June, an additional spray 2 to 3 weeks later with 1/2 pound of DDT in 100 gallons of water to cover the new growth afforded complete protection. When DDT was not used for control of the grape berry moth, protection against the Japanese beetle was obtained by spraying with 1 pound of DDT per 100 gallons of bordeaux mixture late in June and 2 to 3 weeks later with 1 pound of DDT per 100 gallons of water. These sprays protected the following varieties from injury by the beetles:

Butler	Etta	Massasoit	Portland
Caco	Fredonia	Missouri Riesling	Regal
Catawba	Herbert	Muscat	Salem
Champion	Iona	Niagara	Sheridan
Concord	Janesville	Ontario	Telegraph
Cottage	Lindley	Perkins	Wilder
Delaware	Martha	Pocklington	Woodruff Red
			Worden

Occasional feeding occurred on the sprayed foliage of Brighton, Brilliant, Clinton, Lutie, Urbana, and Vergennes.

Hungarian was the only variety that was not adequately protected by these sprays; extensive feeding occurred on the sprayed foliage, and the beetles attacked the fruit.

Blueberry.--In recent years the Japanese beetle infestation in most of the commercial plantings of blueberries in New Jersey has been so light that no special spray has been required. However, some plantations, particularly those adjacent to general farming areas, have invasions which cause damage to fruit and foliage. A heavily infested block, including the varieties June, Rancocas, Scammell, and Stanley, was found at New Brunswick, N. J., in 1943. Early in July these plants were sprayed with 1 pound of DDT per 100 gallons of water. This spray protected the fruit and foliage for 2 weeks. Then the beetles began to attack the terminal growth which had developed after the application of the spray. The plants were resprayed and no further damage occurred.

Ornamental trees and shrubs.--During 1944, 1945, and 1946 several hundred ornamental trees and shrubs at Bridgeton, N. J., Rye, N. Y., and Blowing Rock, N. C., were sprayed with DDT at the rate of 1 pound to 100 gallons of water. The following species were included:

Trees

Fagus grandifolia	American Beech
Quercus montana	Chestnut Oak
palustris	Pin Oak
Tilia americana	American Linden
europaea	European Linden
Ulmus americana	American Elm

Shrubs and Vines

Acer japonica	Fullmoon Maple
palmatum	Japanese Maple
Azalea calendulacea	Flame Azalea
mollis	Chinese Azalea
Berberis thunbergi	Japanese Barberry
Buddleia davidii	Butterflybush
Chaenomeles lagenaria	Flowering Quince
Cotoneaster sp.	Cotoneaster
Lespedeza sp.	Lespedeza
Malus floribunda	Japanese Flowering Crab
Parthenocissus quinquefolia	Virginia Creeper
Prunus serrulata	Oriental Cherry
triloba	Flowering Plum
Rosa spp.	Various hybrid tea roses and the climbing roses Dorothy Perkins and Paul's Scarlet

The DDT protected the foliage, but did not prevent the beetles from damaging the blooms. When the plants did not make much growth, one spray, applied late in June or early in July, was sufficient to protect the foliage. The plants that grew considerably during July required a second application 2 weeks later.

Late in July 1945 ornamental trees and shrubs at Fort Schuyler, N. Y., were sprayed with a solution of DDT in xylene and kerosene by means of a mist blower. The infestation in the trees and shrubs was destroyed, and no further injury occurred during the summer.

Flowering garden plants.--During 1944 and 1945 several beds of flowering garden plants, including marigolds, snapdragons, and zinnias, at Bridgeton, N. J., were sprayed with DDT at the rate of 1 pound per 100 gallons. A spray applied early in July protected the plants for 2 weeks. A second spray, applied 2 weeks later, afforded protection to the plants throughout the summer.

Field crops.--Soybeans, including the varieties Chief, Earlyana, Gibson, Illini, Lincoln, Macoupin, Mingo, Patoka, Richland, and Viking were sprayed with DDT, 1 pound per 100 gallons, at Dover, Del., in 1945. The spray killed many of the beetles on the plants and afforded protection for about 1 week. As the plants made considerable growth during this period, it was necessary to repeat the application at weekly intervals.

On July 25, 1945, a plot of soybeans and several plots of corn at Beltsville, Md., were dusted with 10-percent DDT. Most of the beetles on the soybeans were killed, and a week later only an occasional beetle was seen on the plants. When the dust was applied to the corn, beetles were feeding on 10 to 50 percent of the silks. Two days later no beetles were present, but after a week many were feeding on the old and newly formed silks.

About half of a 30-acre field of hybrid corn near Lebanon, Pa., was sprayed or dusted with DDT on August 2, 1946. The following formulations were used:

A solution prepared by dissolving 1 pound of DDT in 1 quart of xylene and 3 quarts of kerosene.

A commercial emulsion containing 30 percent of DDT dissolved in methylated naphthalene and an unknown emulsifier, diluted 1:3 with water.

A commercial emulsion containing 25 percent of DDT dissolved in an aromatic petroleum derivative and an unknown emulsifier, diluted 1:1 with water.

A dust containing 1 percent of micronized DDT.

All treatments were applied by an airplane, which flew low over the field. The dust was applied at the rate of approximately 45 pounds per acre and the solutions and emulsions at about 1-1/3 gallons per acre. Shortly after the application of these treatments the beetles showed evidence of poisoning, and within an hour many of them had fallen to the ground. Three days later there were 65 percent fewer beetles on the dusted corn and 93 percent fewer beetles on the corn sprayed with the solutions than in the adjacent untreated plot. Seven days later, although the population in the treated plots had not changed, the beetles were feeding on the newly formed silks. It was evident that more than one application of DDT would be required during the silking period to control the beetles on corn.

Control of the Immature Stages in the Soil

In the tests for control of the immature stages in the soil, adult beetles were able to burrow into soil treated with DDT at rates up to 50 pounds per acre without any detrimental effect. Furthermore, eggs hatched and pupae developed normally in treated soil. The only stage susceptible to poisoning by DDT was the larva.

Pound for pound, DDT is about 100 times as toxic to the larvae as is lead arsenate, the material used most extensively in the past for their control. Newly hatched larvae succumb more quickly than do fully grown third instars. DDT is not effective at 40° F., when the larvae are dormant, but the speed of toxic action increases progressively with the rise of the temperature above this point.

The rate of toxic action was the more rapid in sands than in other types of soil, but there was no significant difference in the rates in gravelly loams, sandy loams, loams, and silt loams. DDT poisoned the larvae more rapidly in well-drained soils than in poorly drained, inadequately aerated soils. The rate was retarded by the addition of organic matter, such as peat, but was not inhibited by inorganic fertilizers, such as lime, calcium phosphate, potassium nitrate, ammonium sulfate, and calcium cyanamide, or by aluminum sulfate, ferrous sulfate, or sulfur.

In laboratory studies the effectiveness of DDT in representative soils from the Piedmont Plateau, the Appalachian Mountains, and the Coastal Plain did not change in 3-1/2 years. It appears that DDT will remain insecticidally active in the soil for a long period.

The most effective control of the larvae was obtained when DDT was in the soil at the time the eggs were hatching. Treatments were applied to established turf and to cultivated land in the spring of 1944, 1945, and 1946 with the object of destroying the brood which hatched during the summer. The tests conducted and results obtained may be summarized briefly as follows:

Turf.--In May 1944 DDT was applied as a dust at the rate of 25 pounds per acre to infested turf at Totawa, N. J. The treatment killed one-third of the larvae before pupation. It reduced the 1944-45 brood 90 percent by September and 96 percent by the following May. The 1945-46 brood was reduced 98.9 percent, and the 1946-47 brood 99.8 percent, by September 1945 and 1946, respectively.

In May 1945 DDT was applied to turf at Blowing Rock, N. C., at the rate of 25 pounds per acre. Most of the area was treated with the 10-percent dust, but a small portion was sprayed with a suspension of DDT, at the rate of 25 pounds of DDT in 1,000 gallons per acre. In the dusted area the 1945-46 brood was reduced 78.6 percent by September and 91.6 percent before pupation in June. In

the sprayed area the reduction was 67.4 percent and 90.2 percent, respectively. By October 1946 the DDT dust had reduced the density of the 1946-47 brood by 97.4 percent, and the spray by 64.4 percent.

In May 1946 DDT was applied to turf at the rate of 25 pounds per acre as a dust at Blairstown, N. J., Orange, Conn., and Northampton, Mass., and as a spray at Blairstown, N. J., and New London, Conn. The treatment killed 25.8 percent of the 1945-46 brood at New London and 71 percent of this brood at Orange before pupation. By mid-September the dust had caused a reduction in the 1946-47 brood of 99.7 percent at Blairstown, 84.0 percent at Orange, and 98.5 percent at Northampton, and the spray had killed 99.5 percent at Blairstown, and 82.7 percent at New London.

In July 1946, before most of the eggs had hatched, DDT was applied both as a dust and as a spray to turf at Orange at the rate of 25 pounds per acre. By mid-September the dust had reduced the 1946-47 brood by 88 percent and the spray had reduced it by 83 percent.

One application of DDT as a dust or spray to the surface of established turf at the rate of 25 pounds per acre before the eggs hatched, reduced the larval population to negligible proportions, and from the present indications the treatment will be effective for several years.

Cultivated land in commercial nurseries.--To determine the possibilities of DDT for eradicating the larvae in the soil in beds and plots in commercial nurseries, to satisfy requirements of the quarantine, in the spring of 1944, 1945, and 1946 treatments were applied at the following commercial establishments in New Jersey where various types of ornamental stock were being grown: Browns Mills, Chatsworth, Kingston, Magnolia, Pemberton, Ridgewood, Riverton, Rutherford, Shiloh, Vincentown, Wayne, and Woodstown.

DDT was applied as a water-dispersible powder to established beds at rates ranging from 10 to 50 pounds of DDT per acre, 1,000 gallons of the spray being used per acre. The material was not mixed into the soil. There was a pronounced reduction in the density of the larval population by mid-September in all treatments, but complete elimination was not obtained even with 50 pounds of DDT per acre.

The DDT was also applied as a dust at rates ranging from 10 to 55 pounds per acre and mixed by cultivation with the upper 3 to 4 inches of soil. When less than 25 pounds per acre was applied, few of the plots were entirely free of infestation by mid-September, but at the higher dosages only an occasional larva was found. With the 25-pound treatment 99.9 percent of the population was eliminated. Results equally as good were obtained with the water-dispersible DDT, applied as a spray and mixed with the upper 3 to 4 inches of the soil.

Plots at Riverton and Woodstown, which were treated by applying DDT at the rate of 25 pounds per acre and mixing it with the upper 3 to 4 inches of soil, were left undisturbed for 2 years. This treatment eliminated two successive annual broods.

The results indicate that DDT applied to nursery beds and plots in the spring at the rate of 25 pounds per acre and mixed with the upper 3 to 4 inches of soil will practically eliminate the larvae by mid-September. The indications are that the treatment will be effective for several years. DDT appears very promising for the treatment of beds and plots to satisfy the requirements of the quarantine.

Potting soil.--To determine the possibilities of DDT for the treatment of soil used in commercial greenhouses for potting plants, to satisfy requirements of the quarantine, DDT was mixed with different soils at rates ranging from 2.7 to 108 grams per cubic yard. At 80° F. complete mortality of newly hatched larvae was not obtained with 2.7 grams in 2 weeks, but all the larvae were killed with 5.4 grams in 5 days, with 10.8 grams in 4 days, with 27 grams in 3 days, and with 54 or more grams in 2 days. Third-instar larvae were much more resistant; to obtain complete mortality required 7.2 weeks with 10.8 grams, 4 weeks with 27 grams, and 2.7 weeks with 54 grams.

Twenty-seven grams per cubic yard, which is equivalent to 25 pounds per acre, seemed to be about the optimum amount for the treatment of potting soil. Greater amounts of DDT did not accelerate very much the rate of poisoning and increased the hazard of injuring plants; lesser amounts prolonged the time required to eliminate the infestation too much to be practical. During the summer, if proper allowance is made for the incubation of the eggs, a period of 3 to 4 weeks would be required from the time the eggs are laid in soil treated with this dosage until it was free of infestation.

There is a close correlation between the temperature of the soil and the rate of poisoning. To kill third-instar larvae in soil treated with 27 grams of DDT per cubic yard required 4 weeks at 80° F., 6 weeks at 70°, 8 weeks at 60°, and 16 weeks at 50°.

The type of soil influenced the velocity of poisoning with 27 grams of DDT per cubic yard. At 80° F. to kill third-instar larvae required on an average 2.8 weeks in the sands, 4.4 weeks in the sandy loams, 4.1 weeks in the loams, and 3.9 weeks in the silt loams.

The addition of ammonium phosphate, ammonium sulfate, calcium cyanamide, calcium phosphate, calcium sulfate, and sodium nitrate to potting soil at rates up to 2.5 pounds per cubic yard did not inhibit the insecticidal action of DDT. Hydrated lime at rates up to 40 pounds per cubic yard did not modify the toxicity of the DDT to the larvae. The addition of organic matter tended to retard the velocity of poisoning.

The effectiveness of DDT in the different soils did not change significantly during 3-1/2 years. The addition of the fertilizers and organic matter to the soils did not modify the duration of the effectiveness.

Effect of DDT Treatments for Japanese Beetle Control on Other Insects and Invertebrates

In studying the effectiveness of DDT dusts and sprays for control of the larvae and the adults of the Japanese beetle, it was the practice to make general observations on the effect of the treatments on other insects and invertebrates. When DDT was applied as a spray to fruit and ornamental trees and shrubs, all dead and dying invertebrates beneath the plants were collected and classified. Some representatives of the following groups were affected by DDT:

Arachnida:
  Araneida, Phalangida
Crustacea:
  Oniscoida
Chilopoda
Diplopoda
Hexapoda:
  Coleoptera: Buprestidae, Carabidae, Cerambycidae, Chrysomelidae, Cicindelidae, Coccinellidae, Curculionidae, Elateridae, Lampyridae, Mordellidae, Scarabaeidae

Hexapoda (cont.):
Diptera: Calliphoridae, Larvaevoridae, Muscidae, Rhagionidae, Sarcophagidae, Syrphidae, Tephritidae
Hemiptera: Cicadelliae, Miridae, Pentatomidae, Reduviidae
Hymenoptera: Andrenidae, Apidae, Braconidae, Eumeninae, Formicidae, Ichneumonidae, Tenthredinidae
Lepidoptera: Geometeridae, Lasiocampodae, Phalaenidae, Pyralididae
Odonata: Agrionidae
Orthoptera: Gryllidae, Mantidae

Many insects, including beneficial forms, were killed by DDT, either by being wetted by the spray or by coming in contact with deposits on the foliage or on the ground beneath the trees. There is still much to be done to establish the effect of DDT on the beneficial insect parasites and predators, as well as on insects that assist in the pollination of important crops. In general, DDT appears to be somewhat less injurious to pollinating insects than is lead arsenate.

Spraying the foliage for protection against the Japanese beetle seemed to be of some value in controlling certain other pests. When applied to peaches, the spray reduced the injury to fruit by the oriental fruit moth (Grapholitha molesta (Busck))3/ and seemed to give some control of the peach tree borer (Sanninoidea exitiosa (Say))4/. Substituting DDT for lead arsenate in the last arsenical cover spray for early apples gave better control of the codling moth (Carpocapsa pomonella (L.)). When applied to grapes, DDT practically eliminated the grape leaf folder (Desmia funeralis (Hbn.)) and the grape leafhoppers (Erythroneura spp.), and gave better control of the grape berry moth (Polychrosis viteana (Clem.)) than did lead arsenate. American holly (Ilex opaca Ait.) in a group of shrubs sprayed with DDT had few holly leaf miners (Phytomyza ilicis (Curtis)), but adjacent unsprayed plants had many miners. The spray also controlled the elm leaf beetle (Galerucella xanthomelaena (Schr.)) and the rose chafer (Macrodactylus subspinosus (F.)).

3/ Driggers, B. F. Laboratory test on the oriental fruit moth with special reference to DDT. (Scientific Note) Jour. Econ. Ent. 37: 120-121. 1944.

4/ _____ Field tests of DDT to control the peach borer. (Scientific Note) Jour. Econ. Ent. 37: 657. 1944.

The spray seemed to have no effect on full-grown larvae of the bagworm (Thyridopteryx ephemeraeformis (Haw.)), the grape mealybug (Pseudococcus maritimus (Ehrh.)), or the Comstock mealybug (P. comstocki (Kuw.)), and did not control the grapevine aphid (Aphis illinoisensis Shimer), the rosy apple aphid (Anuraphis roseus Baker), or the apple aphid (Aphis pomi Deg.). It seemed to have no effect on galls on grape vines.

Mites increased markedly on plants subject to attack by this pest following applications of DDT. On azaleas a spider mite (Tetranychus sp., probably bimaculatus Harv. or althaeae Von Haust.) increased rapidly after the spraying, and caused mottling of the foliage. The European red mite (Paratetranychus pilosus (C. and F.) increased rapidly on apples, peaches, and lindens sprayed with DDT, and in August it caused many of the leaves to drop prematurely. It was evident from these results that the control of mites is a problem that must be considered when DDT is used as a spray on foliage.

The application of DDT as a dust to the ground killed large numbers of insects which are found frequently on the surface of the soil or on low-growing vegetation, including many of the ground beetles, particularly of the family Carabidae, blister beetles, grasshoppers, crickets, leafhoppers, and leaf bugs. Sowbugs and crayfish in low spots were killed. Cutworms were usually absent from soil treated with DDT, but wireworms and earthworms seemed to be as abundant as in untreated soil. The effect of DDT on the many species of ants is uncertain; sometimes ants were absent, but in other cases they seemed to be as numerous as in untreated soil. Some garden slugs were killed by coming in contact with the dust, but after the residue had been washed from the blades of grass by rain, the treatment seemed to have no effect on them.

Effect of DDT on Plants

There have been very few cases where spraying the foliage with DDT at the rate of 1 pound per 100 gallons of water has caused any direct damage to the plants. No injury was observed on the following plants:

Deciduous fruits (all varieties that were sprayed):

Apple	Grape	Peach
Blueberry	Nectarine	Plum

Ornamentals:

Azalea calendulacea	Flame Azalea
mollis	Chinese Azalea
Berberis thunbergi	Japanese Barberry
Buddleia davidii	Butterflybush
Chaenomeles lagenaria	Flowering Quince
Fagus grandifolia	American Beech
Lespedeza sp.	Lespedeza
Malus floribunda	Japanese Flowering Crab
Parthenociccus quinquefolia	Virginia Creeper
Prunus serrulata	Oriental Cherry
triloba	Flowering Plum
Quercus montana	Chestnut Oak
palustris	Pin Oak
Tilia americana	American Linden
europaea	European Linden
Ulmus americana	American Elm

Flowering garden plants:

Marigold Snapdragon Zinnia

Spraying with water-dispersible DDT may have caused some chemical burning on the foliage of Japanese maple (Acer palmatum) and fullmoon maple (A. japonica), but this is uncertain because these varieties are very susceptible to scalding by the sun during the summer. It injured slightly the blooms on roses and on petunias and definitely retarded the growth and reduced the yield of soybeans.

Applying DDT dissolved in xylene and kerosene with a mist blower did not damage the foliage of various deciduous trees and shrubs. Corn was not injured while in silk by dusting or spraying emulsions and solutions of DDT from an airplane.

Preliminary tests were made at the laboratory and conducted cooperatively with 54 commercial establishments in a number of eastern States to determine whether various plants could be grown satisfactorily in soil containing 25 pounds of DDT per acre, or 27 grams per cubic yard. The plants were grown in treated soil and compared with those in untreated soil. The results are indicated below.

Plants Not Noticeably Affected by DDT in Soil

Vegetables:

Beta vulgaris	Common Beet
Brassica chinensis	Chinese Cabbage
oleracea acephala	Kale
capitata	Cabbage
rapa	Turnip
Capsicum sp.	Pepper
Cucumis melo	Muskmelon
sativus	Cucumber
Cucurbita maxima	Squash
Daucus carota sativa	Garden Carrot
Lactuca sativa	Garden Lettuce
Pastinaca sativa	Garden Parsnip
Pisum sativum	Garden Pea
Raphanus sativus	Garden Radish
Solanum melongena	Garden Eggplant
tuberosum	Potato
Zea mays	Corn

Cereals and grasses:

Agrostis alba	Redtop
palustris	Creeping Bentgrass
tenuis	Colonial Bentgrass
tenuis astoriana	Astoria Bentgrass
Avena sp.	Oats
Cynodon dactylon	Bermudagrass
Dactylis glomerata	Orchardgrass
Festuca elatior	Meadow Fescue
rubra commutata	Chewings Fescue
Hordeum vulgare	Barley
Lolium perenne	Perennial Ryegrass
Poa compressa	Canada Bluegrass
pratensis	Kentucky Bluegrass
trivialis	Rough-stalk Bluegrass
Secale cerale	Rye
Stenotaphrum secundatum	St. Augustinegrass
Triticum sp.	Wheat

Ornamentals:

Acalypha hispida	Chenille Copperleaf
Acanthus montanus	Acanthus
Acer palmatum	Japanese Maple
Achillea ptarmica	Sneezewort Yarrow
Aechmea calyculata	
caudata	
fasciata	
fulgens	
weilbachia	
Aeschynanthus pulcher	Scarlet Basketvine
Ageratum sp.	Ageratum
Aglaonema commutatum	
costatum	
simplex	Chinagreen
Allamanda cathartica hendersoni	Henderson Common Allamanda
Alpinia sanderae	Banded Galangal
Althaea rosea	Hollyhock
Amomum cardamon	Cardamon Amomum
Ananas comosus	Pineapple
Anthemis tinctoria	Golden Camomile
Arabis alpina	Alpine Rockcress
Araucaria excelsa	Norfolkisland Pine
Ardisia crenulata	Ardisia
Aregelia marmorata	Airplant Aregelia
spectabilis	Showy Aregelia
tristis	Bitter Aregelia
Arenaria verna caespitosa	Moss Sandwort
Armeria sp.	Thrift
Aronia arbutifolia	Red Chokeberry
Aspidistra elatior variegata	Striped Aspidistra
Aster subcoeruleus	East Indies Aster
thomsoni frikarti	Frikart Aster
Azalea indica	Indica Azalea
kaempferi	Torch Azalea
kurume	Kurume Azalea
mollis	Chinese Azalea
rosmarinifolia	Snow Azalea
rutherfordiana	Rutherford Azalea
sanderi	Sander Azalea
Begonia coccinea x olbia	
foliosa	
heracleifolia	
imperialis	Imperial Begonia
maculata argentea	Spotted Begonia
manicata aureo-maculata	

Ornamentals (cont.):

Begonia metallica	Steel Begonia
nitida odorata	Glossy Begonia
rex	Assamking Begonia
semperflorens	Perpetual Begonia
Berberis mentorensis	Mentor Barberry
verruculosa	Warty Barberry
Billbergia alberti	Albert Airbrom
beucker	
distachya	
nutans	Bleurim Airbrom
pyramidalis	Violetrim Airbrom
quintitissima	
sanderiana	Sander Airbrom
zebrina	Zebra Airbrom
Buddleia sp.	Butterflybush
Buxus sempervirens	Common Box
sempervirens suffruticosa	Truedwarf Box
Calathea makoyana	Makoy Calathea
ornata roseilineata	Roseline Bigleaf Calathea
vandenheckei	Vandenheck Calathea
Calceolaria sp.	Calceolaria
Calendula sp.	Calendula
Camellia japonica	Common Camellia
Campanula carpatica	Carpathian Bellflower
persicifolia	Peachleaf Bellflower
rotundifolia superba	Bluebells of Scotland
Canna sp.	Canna
Catananche caerulea	Blue Cupidsdart
Cerus candelaris	Candle Cactus
Chamaecyparis lawsoniana	Lawson Falsecypress
nootkatensis glauca	Blue Nootka Falsecypress
obtusa gracilis	Slender Hinoki Falsecypress
pisifera	Sawara Falsecypress
Chlorophytum elatum	Bracketplant
Chrysanthemum sp.	Chrysanthemum
Cibotium schiedei	Mexican Cibotium
Cissus discolor	Begonia Treebine
rhombifolia	Venzuela Treebine
sicyoides	Waterwithe Treebine
Clerodendron thomsonae	Bleedingheart Glorybower
Codiaeum varietgatum	Leafcroton
Coleus sp.	Coleus
Cordyline terminalis	Common Dracena
Coreopsis tinctoria	Calliopsis

Ornamentals (cont.):

Cornus florida	Flowering Dogwood
Cotoneaster acutifolia	Peking Cotoneaster
Crassula arborescens	Crassula
Croton punctatus	
Cryptanthus acaulis	
terminalis	
Cryptomeria japonica lobbi	Lobb Cryptomeria
Ctenanthe oppenheimiana	
Cyclamen sp.	Cyclamen
Daphne cneorum	Rose Daphne
Davallia fijiensis plumosa	Fiji Davallia
Delphinium sp.	Larkspur
Dianthus caryophyllus	Carnation
plumarius	Grass Pink
Dicentra spectabilis	Common Bleedingheart
Dieffenbachia bausei	Bause Tuftroot
leoni	Leon Tuftroot
picta	Variable Tuftroot
splendens	Whitespot Tuftroot
Doronicum caucasicum	Caucasian Leopardbane
Dracaena deremensis warnecki	
fragrans massangeana	Massange Dracaena
victoriae	Victoria Dracaena
godseffiana kelleri	Keller Dracaena
goldieana	Goldie Dracaena
gracilis	
longi	
Episica coccinea	
Erigeron speciosus	Oregon Fleabane
Euonymus fortunei vegetus	Bigleaf Wintercreeper Euonymus
Eupatorium coelestinum	Mistflower Eupatorium
Euphorbia pulcherrima	Oakleaf Poinsettia
Ficus elastica	Indiarubber Fig
radicana variegata	Variegated Rooting Fig
Fittonia verschaffeltii	Tall Fittonia
Fuchsia sp.	Fuchsia
Ginkgo biloba	Ginkgo
Gypsophila repens	Creeping Gypsophila
Hedera canariensis	Algerian Ivy
helix	English Ivy
Heliopsis sp.	Heliopsis
Heliotropium sp.	Heliotrope
Hemigraphis colorata	
Herniaria glabra	Common Burstwort
Heuchera rosmundi	Rosemund Alumroot

Ornamentals (cont.):

Hoffmannia ghiesbreghti	
refulgens	
Homalocladium platycladum	Ribbonbush
Homalomena wallisi	
Hoya carnosa	Common Waxplant
Hydrangea macrophylla	Bigleaf Hydrangea
Hypericum sp.	St. Johnswort
Iberis sempervirens	Evergreen Candytuft
Ilex glabra	Inkberry
opaca	American Holly
Impatiens sultani	Sultan Snapweed
Jasminum officinale affine	
sambac	Arabian Jasmine
Juniperus chinensis	Chinese Juniper
communis	Common Juniper
excelsa	Greek Juniper
horizontalis	Creeping Juniper
scopulorum	Rocky Mountain Juniper
squamata	Singleseed Juniper
virginiana	Eastern Redcedar
Kalanchoe blossfeldiana	Kalanchoe
Laburnum anagyroides	Goldenchain Laburnum
Lonicera henryi	Henry Honeysuckle
Magnolia soulangeana	Saucer Magnolia
stellata	Star Magnolia
Mahonia aquifolium	Oregongrape
Maranta arundinacea	Bermuda Arrowroot
bicolor	
leuconeura kerchoveana	Redspot Banded Arrowroot
Matricaria tchihatchewi	Silver Ball Turfingdaisy
Medinilla magnifica	
Myosotis scorpioides	True Forgetmenot
Nepeta mussini	Persian Nepeta
Nephrolepis exaltata bostoniensis	Bostonfern
Nephthytis afzeli	
Nidularium amazonica	
fulgens	
innocenti	
purpureum	
Ophiopogon japonicus	Lilyturf
Pachysandra terminalis	Japanese Pachysandra
Pandanus baptisti	
veitchi	Veitch Screwpine
Papaver orientale	Oriental Poppy
Parthenocissus tricuspidata	Japanese Creeper

Ornamentals (cont.):

Passiflora alatocaerulea	White Passionflower
racemosa	
Pelargonium sp.	Garden Geranium
Pellionia daveauana	
Penstemon garretti	Garretts Penstemon
Peperomia obtusifolia	Ovalleaf Peperomia
sandersi	Sanders Peperomia
Petunia sp.	Petunia
Philodendron cordatum	Heartleaf Philodendron
dubium	
hastatum	
Phlox divaricata	Sweetwilliam Phlox
glaberrima	Smooth Phlox
nivalis	Trailing Phlox
Phyllitis scolopendrium cristatum	Hartstongue Fern
Picea glauca	White Spruce
pungens	Colorado Spruce
Pieris japonica	Japanese Pieris
Pilea muscosa	Clearweed
Pinus mugo	Swiss Mountain Pine
Polystichum sp.	Hollyfern
Potentilla fruticosa	Bush Cinquefoil
Primula veris	Cowslip Primrose
Pseudotsuga taxifolia	Douglasfir
Pteris cretica	Cretan Brake
tremula	Australian Brake
Pulmonaria saccharata	Bethleham Lungwort
Pyracantha coccinea lalandi	Laland Firethorn
Rorippa nasturtium-aquaticum	Watercress
Rosa sp.	Rose
Rubus reflexus pictus	
Salvia sp.	Sage
Sansevieria zeylanica	Ceylon Sansevieria
Saxifraga sarmentosa	Strawberry Saxifrage
Scindapsus aurens	Solomonislands Ivyarum
Scirpus cernuus	Weeping Bulrush
Spiraea sp.	Spirea
Taxus baccata	English Yew
brevifolia	Pacific Yew
cuspidata	Japanese Yew
hunnewelliana	Hunnewell Yew
media	Anglojap Yew
Teucrium chamaedrys	Chamaedrys Germander
Thalictrum glaucum	Dusty Meadowrue

Ornamentals (cont.):

Thuja occidentalis	Eastern Arborvitae
orientalis	Oriental Arborvitae
Tillandsia lindeniana	Lindens Tillandsia
Tolmiea menziesi	Pick-a-Back Plant
Trachelospermum jasminoides	Chinese Starjasmine
Tradescantia fluminensis	Wanderingjew
Tropaeolum sp.	Nasturtium
Vaccinium sp.	Blueberry
Veronica sp.	Speedwell
Viburnum burkwoodi	Burkwood Viburnum
carlesi	Koreanspice Viburnum
dilatatum	Linden Viburnum
setigerum	Tea Viburnum
tomentosum	Doublefile Viburnum
Vinca sp.	Periwinkle
Viola cornuta	Horned Violet
odorata	Sweet Violet
tricolor hortensis	Garden Pansy
Vitis sp.	Grape
Vriesia erecta	Poelrex Vriesia
favorita	
magnifica	
Weigela sp.	Weigela
Xanthosoma lindeni	Linden Malanga
Zinnia sp.	Zinnia

Plants Definitely Retarded by DDT in Soil

Vegetables:

Allium flavum	Yellow Onion
Glycine soja	Soybean
Lycopersicon esculentum	Common Tomato
Phaseolus limensis	Lima Bean
vulgaris humilis	Bush Bean
Spinacia oleracea	Spinach

Ornamentals:

Alyssum saxatile citrinum	Goldentuft Alyssum
Fragaria sp.	Strawberry
Gaillardia sp.	Gaillardia
Lobelia sp.	Lobelia
Scabiosa sp.	Scabious

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There is some evidence that the detrimental effect of technical DDT in the soil on some plants is not caused by the compound, but by impurities and certain isomers in the technical material. Bush beans, lima beans, and tomatoes did not tolerate 25 pounds per acre of the technical, DDT but grew normally in soil containing 200 pounds of purified DDT per acre.

Effect of DDT on Warm-blooded Animals

In the experimental work with DDT for control of the Japanese beetle, some birds, principally robins and catbirds, were killed, probably by feeding on poisoned insects. When DDT was applied as a dust to the ground, it was urged that horses, cows, goats, chickens, ducks, and other animals be excluded from the treated area until rain had removed most of the dust from the foliage. No harm to stock was observed when this procedure was followed, but much more information is desired on the reactions of various animals after feeding on plants treated with DDT.

Residue of DDT on Food Crops

Fruit picked immediately after being sprayed with water-dispersible DDT, 1 pound per 100 gallons, with summer-oil emulsion added as a sticker, had a residue of more than 7 mg. per kilogram. Apples picked 6 days after spraying and passed through a wiper had a residue which approached this amount; apples picked 2 weeks after spraying and wiped in the same manner had a residue well below this. Peaches picked 2 weeks after spraying and passed through a "defuzzer" had a residue less than 7 mg. per kilogram. When more than one application of this spray was made to peaches and grapes during the summer, the residue on the fruit at harvest was definitely above 7 mg. per kilogram.

When the sticker was omitted, apples picked 3 weeks after one application of the spray had a residue of 2.5 mg. per kilogram, and peaches picked 3 to 4 weeks after spraying had 4.7 to 6 mg. per kilogram. Grapes sprayed three times with 1 pound of water-dispersible DDT and once with 1/2 pound of the material per 100 gallons had a residue of 3.8 mg. per kilogram at harvest.